THE MICROCOSM OF SCIENTIFIC KNOWLEDGE: SCIENTISTS ARE TALKING, BUT MOSTLY TO EACH OTHER

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ABSTRACT

Communication of results has long been recognized as the final step in the scientific process. Publication in scientific journals has been the accepted method of communication. In the years 1990-1991 there were over 5,300 accredited scientific journals in print indexed by ISI. However, far less than 1% of the papers published in those journals were subsequently reported on in the top mainstream printed news media. Well over 99% of the scientific papers published failed to be noticed by mainstream publications and mainstream audiences. This begs the question, that as scientists, is it sufficient to publish results in highly technical formats with only scientists as the intended audience? Or, has this trend caused a great disparity between the knowledgeable elite and the general public? This paper examines the highest circulated news magazines and newspapers during the period of 1990-1991. Every paper reported on, and the general topic of every scientific news article, as well as the scientists referenced, were compiled. Those results were compared to the top papers that were published in scientific journals during that same time period. The goal was to determine if there was any correlation between the two based on popularity of topics or likelihood of being cited and reported on. The results show that overwhelmingly, nearly every paper reported on appeared only in either the *New England Journal of Medicine*, the *Journal of the American Medical Association*, *Science* or *Nature*. Further, this study shows that there was some correlation among popularity of topics covered in mainstream publications and journals, but in the key fields of the environment and science education,

there was a sizable disparity. Most striking was the extremely low number of papers that ever made it to the general public. At a time when disciplines are scratching their heads and wondering "what next?" for their fields, once hot topics such as evolution and global warming are fighting to keep a foothold in popular scientific understanding. This paper highlights the major chasm that exists between academia and the mainstream. It points to a clear need for scientists to make new efforts to communicate not just to a captive audience of fellow researchers, but to the mainstream decision-makers of the world. Since the majority of the public looks to mass media for scientific news, it is essential that the scientific community open channels of communication with media and learn alternate forms of communication. As Albert Einstein astutely pointed out in 1954, "It is just as important to make knowledge live and to keep it alive as to solve specific problems."

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CHAPTER 1

INTRODUCTION

There exists a disconnect between scientists and the main stream decision-makers of the United States. An overwhelming majority pf people, 90%, according to the 2001 National Science Foundation (NSF) survey, are very or moderately interested in new scientific discoveries (NSF, 2001). Yet, according to that same survey, less than 15% of the respondents claimed to be well-informed about science and scientific discoveries. And they are correct. NSF has concluded that most Americans do not know a lot about science and technology. When asked if humans coincided with dinosaurs, the majority of respondents in their survey said "yes." And only around 50% of the respondents knew that it takes Earth one year to go around the Sun and that electrons are smaller than atoms (NSF, 2001).

There are over 5,200 accredited scientific journals indexed by the Institute for Scientific Information (ISI), which turn out an estimated 200,000 scientific papers every year (NSF, 2004). With this preponderance of new scientific discoveries and an audience ripe for learning about new scientific discoveries, it would seem that there would exist a multitude of fruitful scientists and an extremely well-informed public. But, that is not the case.

Is the problem that respondents are exaggerating about their overall interest in science? Surveys conducted by the Pew Research Center for the People and the Press found that the topic of "Science and Technology" ranked an unimpressive 9 out of 13 categories of news that the public followed closely in 2002. Is the problem that scientific papers are full of many things but rarely new scientific discoveries as Dr. Rustum Roy postulated in his 1991 paper titled "Funding Academic Research?" (Rustum, 1991) Perhaps those both are factors in the disconnect, but this paper attempts to highlight a much simpler explanation.

When asked the basic question about where they get their information regarding scientific discoveries, respondents overwhelmingly reported mainstream news media as their primary source (81%). The remainder was divided among the internet (of which a portion is likely also main stream media), friends/colleagues, and other sources not listed (NSF, 2001). However, while people turn to the media for scientific information, scientists have an overall negative attitude towards mainstream media, and a surprisingly low opinion of other scientists who communicate directly with mainstream media. This phenomenon was highlighted by what former NASA administrator Daniel Goldin calls the "Carl Sagan effect," in reference to the late Carl Sagan who was effectively snubbed by many of his colleagues for putting as much energy into communicating as researching (Hartz and Chappell, 1997). Publication to journals is so widely accepted as *the* form of communication of new discoveries from scientists that NSF uses the number of articles published in journals as the one indicator for the output of scientific and technological research (NSF, 2004).

This leaves a very simple explanation for why new scientific discoveries do not make it to an admittedly eager mainstream population. Scientists are talking to scientists, the news media is talking to the mainstream population, but scientists are not talking to the mainstream media.

In recognizing the desire of audiences to read about scientific discoveries, science journalist Jim Hartz and veteran NASA scientist Rick Chappell joined forces to produce "World's Apart," a comprehensive study to understand media coverage and media attitudes as they relate to science. Their study revealed that overall scientists have a very low opinion of mainstream media. When asked to rank each form of media from poor to excellent, the majority ranked nearly every form as solidly poor (Hartz and Chappell, 1997). Even worse was the low opinion scientists had of journalists in particular, with a huge 91% of scientists believing that journalists lack basic understanding of the nature of science. It may be surprising to learn, however, that in that same study, journalists were in agreement with scientists in their opinion of themselves, with 77% also feeling they lacked understanding of the nature of science (Hartz and Chappell, 1997).

The goal of this paper is to expose how the scientific community, by relying primarily on publication of papers to disseminate information, is failing to communicate beyond its borders. Specifically, it will show (1) how extremely unlikely it is for information in a paper published in a scientific journal to make it to a mainstream audience, (2) what trends exist between science articles published in mainstream news magazines and papers published in scientific journals, and (3) that using papers as a communication tool has resulted in a failure on the part of scientists to communicate science to the public.

CHAPTER 2

METHODS

Since most respondents to NSF's survey reported getting their information on new scientific discoveries from mainstream media, and since the standard of communication of new scientific discoveries is publication to scientific journals, it was necessary to determine the number of scientific papers that were reported on in mainstream media. There is no historical database of television news broadcasts, therefore, for this study it was decided to isolate the most popular news magazines, *Time* and *Newsweek*, as the sources of mainstream media used in this study. While the majority of respondents claim that television was their primary news source, mainstream news magazines ranked a distant second. In 2001 the number of people who used news magazines for their primary scientific new source was in 16%, and 1992 is was 28% (the drop was likely due to the increased use of the internet which ranked 9% in 2001, but was not a possible answer in 1992) (NSF, 2002). It is not known how many people used news magazines as secondary sources, but it is expected that the total number of people who receive science news from print magazines is larger than the number who use news magazines as a primary source.

Time and *Newsweek* are both weekly publications, with a combined paid circulation nearing 10 million according to the Audit of Bureau of Circulations International figures prepared in 2003 (BPA, 2003). *Time* is ranked as the top news magazine according to circulation, where *Newsweek* is ranked a close second. The issues of *Time* used for this study were volumes 135 – 138, totaling 106 issues. The issues of *Newsweek* used for this study were volumes 115-118, totaling 105 issues.

Data was collected from *Time* and *Newsweek* magazines for the years 1990 and 1991. Since the intention was to draw conclusions about the likelihood of a paper being reported on based on its citation history, it was necessary to go back in time enough to allow for the citations to have accumulated. It was also important to use target years that preceded widespread use of the internet as a source for information.

For the first part of the study, the methods used were very straightforward. Every article published in *Time* and *Newsweek* for the years 1990 and 1991 was compiled and reviewed. If the article pertained to science, it was assigned to one of the 7 categories listed in Table 1. Here it was necessary to take some liberties in determining if an article was truly about science. For instance, to illustrate this point, an article about diabetes that mentioned celebrities who have it such as Mary Tyler Moore was included as a Health/Medicine article, but an article about Mary Tyler Moore that mentioned she has diabetes was omitted.

Each article was further reviewed for any reference to a paper or journal. If a paper was mentioned, the primary authoring scientist, if given, was recorded as well as the scientific journal that the paper was published in. There were no instances of a paper being mentioned by title, so paper titles could not be used to cross-reference articles. For papers that were referenced merely by a scientist's name and attributed to being published recently in "a scientific journal," the papers were correlated by name and date to determine which scientific journals they appeared in. This was only a few cases, and all were matched with negligible conjecture.

Beyond that, it was deemed of use to determine if publication in a specific scientific journal increased the likelihood of a paper being reported on in mainstream media. To determine this, the science articles in the magazines that related to a paper were further categorized according to which scientific journal the paper had appeared in, and the results were compiled in order to determine which other journals, if any, were favored among *Time* and *Newsweek.*

While the total number of journals in print runs into the tens of thousands, for this study, the group was limited to the journals indexed by the ISI. During the target years of 1990 and 1991, ISI indexed 5,300 journals. The total papers published in those journals during those two years was 1,385,315 (ISI). In order to further analyze trends, the total number of papers published in *Science* and *Nature* combined during those two years was compiled and found to be 12,235 (ISI).

To analyze the likelihood of a paper being reported on in a mainstream news magazine, the percentage of likelihood was calculated by taking the total number of papers reported on in the magazines and dividing it by the total number of papers published in scientific journals. Because of the disproportionately high number of papers reported on that were from the journals the *New England Journal of Medicine (NEJM)* and the *Journal of the American Medical Association* (*JAMA)*, the percentages were also calculated for the likelihood of a paper appearing in either *Science* or *Nature* being reported on, and the likelihood of a paper published in any other journal being reported on in mainstream media.

To determine if there was any correlation between the popularity of topics covered in the mainstream magazines and the topics of papers that appeared in scientific journals, the study group of scientific papers was focused down to the two popular general science journals, *Science* and *Nature*, and the medical journals *NEJM* and *JAMA*. Since early results showed that it was likely that the highest correlation should exist between papers published in *NEJM, JAMA*, *Science* and *Nature* and the articles published in mainstream news magazines, the topics were limited to those four journals. All papers in *NEJM* and *JAMA* were treated in general as health/medicine. The papers in *Science* and *Nature* were categorized according to topic. Since keywords proved an ineffective method of categorizing papers in Science and Nature, each paper in each journal during the target years of 1990 and 1991 was reviewed and assigned to the same categories used for the magazine science articles.

To determine if there existed any correlation between the likelihood of a paper being published and the number of citations that it received, the total number of citations as of 2004 was tabulated for each paper that was reported on in *Time* and *Newsweek.* Papers were organized per journal for *Science* and *Nature*, with the remainder of the journals being grouped together with the exception of *NEJM* and *JAMA* which were not considered for this study.

The total number of science articles appearing in each specific issue of *Time* and *Newsweek* was also recorded in order to determine if there existed any predetermined quotas on the part of *Time* or *Newsweek* pertaining to the number of science articles that they published. For this, the total number of science articles per issue of each magazine was compiled.

CHAPTER 3

RESULTS

From the data compiled from *Time* and *Newsweek*, it was determined that 551 articles pertaining to science were published in *Time* and *Newsweek* in the years 1990 and 1991. Of those, approximately 89 referenced or were related to a scientific paper. Since there were 1,385,315 papers published in the 5,400 journals indexed by ISI, this made the overall likelihood of a paper published in a journal in 1990-1991 being reported on *Time* or *Newsweek* 0.00006%.

When the papers reported on were categorized according to which scientific journal the papers were originally published, the majority of papers reported on belonged to the *New England Journal of Medicine* and the *Journal of the American Medical Association*. Since both of these journals cover the similar general topic of health/medicine, the results for the purpose for this study have been combined, with 50 total papers reported on originating in one of those two journals. Figure 1 shows a breakdown of the scientific journals that had papers that were subsequently reported on. *Science* and *Nature* follow a distant third and fourth place, with 10 and 12 papers each respectively. The remainder of the journals represent a combined total of 8. It is of note that 26 additional articles credited representatives, hearings or reports from the National Academy of Science, 9 of which were attributed to reports released by the NAS and thus are included in the paper totals.

Since *NEJM, JAMA, Science* and *Nature,* which totaled 18,512 papers combined during 1990-1991, represent only 1.33% of the total papers published, this yielded some surprising results. The overall likelihood of a paper being reported on in a mainstream news magazine was 0.00006%. If papers from *NEJM* and *JAMA* are removed, that likelihood reduces to 0.00028%. And for papers that are published in any journal other than *NEJM, JAMA, Science* or *Nature*, the likelihood of being reported on in a mainstream news magazine shrunk to a miniscule 0.000006% based on the 8 papers that were reported on from other journals divided by the 1,366,803 papers published in journals other than *NEJM, JAMA, Science* or *Nature*.

When the popularity of topics between science articles in the magazines and those published in *NEJM, JAMA, Science* and *Nature*, both showed the highest number of articles on the topic of health/medicine. The percent of medical/health articles published in *Time* and *Newsweek* during this period was 46%, where the percent of medical/health articles that were published in *NEJM, JAMA, Science* and *Nature* was 65%. When *NEJM* and *JAMA* were removed and topics covered in *Science* and *Nature* were examined independently, the results, given in Figure 2, showed that for some topics such as the environment there existed a strong correlation between popularity of topics. But, for other topics, such as chemistry, there existed almost no correlation.

The sources of information for the science articles published in *Time* and *Newsweek* were not compiled, but it is important to mention that among those sources were industry representatives, scientists (affiliated with hospitals, universities and organizations such as NSF), and reports released by government bodies such as the NAS, and Environmental Protection Agency. It is also important to note that many articles related to ballot issues, law suits, and other timely issues that made the science articles topical. Along those lines, it is also important to note that some timely news events occurred during these years which may have led to an increase in the number of articles published on certain topics or may have influenced the total number of science articles published during these years. Notably, the launching and subsequent problems with the Hubble telescope may account for a high number of space science articles during this time period, and the first Iraq War and the events leading up to it may have influenced the total number of science articles printed overall.

The total citations of the papers published for the journal *Science* that were reported on in *Time* and *Newsweek* were 3,139 distributed over 8 papers. 2 papers were omitted from the calculation because, although they were attributed to papers in the journal, no corresponding papers could be found using the information provided in the articles. That is, 2 papers were attributed to the journal *Science*, but could not be identified from the information given in the article. This left an average of 392.4 citations per paper. The lowest number of citations was 93, the highest number of citations was 1138. The median number of citations was 312.5.

The total citations of the papers published from the journal *Nature* that were reported on in *Time* and *Newsweek* were 7106 distributed over 12 papers. This left an average of 592.2 citations per paper. The lowest number of citations was 4, the highest number of citations was 1975. The median number of citations was 222.5.

The average number of citations for the remained of the papers referenced in *Time* and *Newsweek* that were attributed to journals other than *Science, Nature, NEJM*, or *JAMA* was 74.7. The lowest number of citations was 34. The highest number of citations was 139. The median number of citations was 52. Figure 3 shows the distribution of each paper that was reported on according to which journal it originated in.

When the papers and corresponding citations were examined to see if any trend existed among papers of certain topics, Health/medicine ranked the highest with 6756 and Space science ranked the lowest with 107 citations. Table 2 lists each paper reported on in *Time* and *Newsweek* that originated in either *Science* or *Nature* according to which category it belongs.

When the number of science articles in *Time* and *Newsweek* were examined for any trends in total numbers per issue, the minimum number of science articles in any given issue was zero, which occurred in 13 out the 551 issues published during 1990 and 1991. The maximum number of science articles published was 6, which occurred in 10 out of the 211 issues published during those years. While either magazine may have an expected minimum and maximum quota, none was revealed by the numbers of articles printed per magazine. The average number of science articles per issue was 2.6.

CHAPTER 4

CONCLUSION AND DISCUSSION

With a less than 0.00006% chance of having results printed in a paper in any journal other than *NEJM, JAMA, Science* and *Nature,* it is clear that it is insufficient and arguably irresponsible to rely on paper publication as a means to disseminate scientific findings to a broad audience. The data presented shows a very clear message that papers published in scientific journals are not being communicated beyond the boundaries of the scientific community.

The breakdown of what the source journals were for the papers that were subsequently reported on was not surprising. NEJM and JAMA are popular journals that while they are not read by the mainstream, their names are familiar and often referenced in the media. *Science*, *Nature* and *Proceedings from the NAS* are journals that rank in the top 5 of the most-cited journals according to ISI, and therefore are also logical sources of high-profile papers. It is also clear from the number of times that the NAS was referenced in articles that they have established communication channels that would facilitate reporting efforts. What was surprising is the extremely low chance a paper published in any other journal, even a high-profile field-specific journal, has of being reported on in the mainstream. This is a clear indicator that publication to any journal beyond the most-cited warrants additional dissemination efforts.

When comparing the categories of science articles published in Time and Newsweek to the topics of papers published in Science and Nature, most categories showed similar percentages. Of note is the high amount of environment and ecology articles that were published compared to the papers of the same topic. This may be evidence of a missed opportunity, where news magazines found a receptive audience for environmental issues. Also of note is the large percentage of science education and research papers published compared to articles published on the topic. While it is likely that some papers concerned what could be considered "in house" information relevant only to scientists, it is likely this was also a missed opportunity where science viewed this topic as timely, but the information failed to make it to the mainstream.

Citation numbers that were compiled showed above average results for all categories, with averages ranges from 74.7 to 682.5 citations per paper. This may be a cause an effect issue, where papers that were profiled in news magazines received a great deal of publicity and this in turn resulted in more citations. Or, the researchers involved sought publicity because the papers warranted them, and citations would naturally flow from publication.

While the value of scientific papers is not being challenged in this paper, their value as tools for dissemination of information is. Some may want to point to the credibility of journalists, the credibility of scientists, their respective motives, their understanding of issues as causes for this disparity, but all of that is really irrelevant. Mainstream audiences get their information from mainstream media. If we as scientists have any desire to communicate our discoveries to that audience (and by and large we should) then we need to move the argument over to how we can better communicate to the media and pull it away from why.

While the scientific community has grappled with its reservations about mass media, this has led to a near breakdown of communication between the two, leaving journalists with a small 15% of scientists they consider accessible. While journalists have been anxious to provide their audiences with scientific news stories, they have found their efforts limited by two failures on the part of scientists. First, a majority complained that scientists are "so intellectual and immersed in their own jargon that they can't communicate with journalists or the public." And second, scientific papers were written with relevance to the public at large often omitted (Hartz and Chappell, 1997).

To combat the first issue, it seems necessary to recognize that scientific papers are tools meant to facilitate communication between scientists. Communication to other audiences requires formulation of results in a different format. Writing a scientific paper is a learned skill, and does not preclude general rhetorical writing skills. In recognition of this, many universities are now including writing courses and mass media communication courses as part of their science curriculums. The London Imperial College of Science, Technology and Medline began such a program in 1991 and detailed their efforts in the paper "Science and the Media," which as of today has been cited 0 times. The UK has taken the lead on this issue, with the preparation of a comprehensive report on science and the public in 2000 and widespread continual efforts as the government level to make science more cooperative (House of Lords, 2000). In support of this idea, I have included a summery of this paper suitable for a mainstream audience in Appendix B.

Addressing the second point stems easily from addressing the first. While many may feel the benefit of a paper is implied, simply spelling out the benefit would meet the needs of journalists who wish to communicate it to their audiences. If a paper has no relevance to readers than it is arguably of significance only to scientists, or lacking deeper merit.

The value of public understanding of science has largely been taken for granted in this paper. Many have postulated on its worth, and there is a wide consensus that in exchange for the $32 billion that are put into public funding of scientific research information and results should be given to the tax payers who fund the majority of it (NSF, 2004).

While a slim majority of scientists surveyed by Research! America claim to participate in outreach programs according to a 2001 survey, since the majority of respondents to NSF's survey claimed to use mainstream media as their primary source for scientific news, it is not clear what effect these outreach programs have, and to what extent increasing them will have. And while the role many scientists play as educators should not be diminished, the level of education people receive seems only to heighten their desire to be informed about scientific discoveries in the future, as evident in the NSF survey. People holding graduate degrees and above ranked themselves as being poor to moderately well-informed about space exploration, new scientific discoveries and environmental pollution, but showed the highest degree of interest in receiving scientific news. It would seem then that it is not a lack of understanding that is creating this shortfall of knowledge, it is lack of dissemination.

The disconnect between science and the mainstream population is, at least in part, due to a breakdown in communication between scientists and the public. While many efforts have been made to bridge that gap by increasing political involvement, community involvement and outreach programs, it would seem that the most success might be enjoyed by taking advantage of the opportunity that already exists by communicating to the mass media that the public already looks to for information. In this way, through what might be compared to wholesale distribution, scientists can reach a far broader audience than if they attempt to reach the public on their own. It requires a new form of communication, but as scientists, communication is a necessary and required part of the scientific process that can not be forgotten.

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FOOTNOTES

[1] citation formatted to conform to the requirements of the House of Parliament
[2] citation formatted to meet guidelines of the National Academy of Sciences
[3] citation formatted to meet guidelines of the National Academy of Sciences

APPENDIX A

FIGURES AND TABLES

Distribution of Journals that Contributed to Science Articles

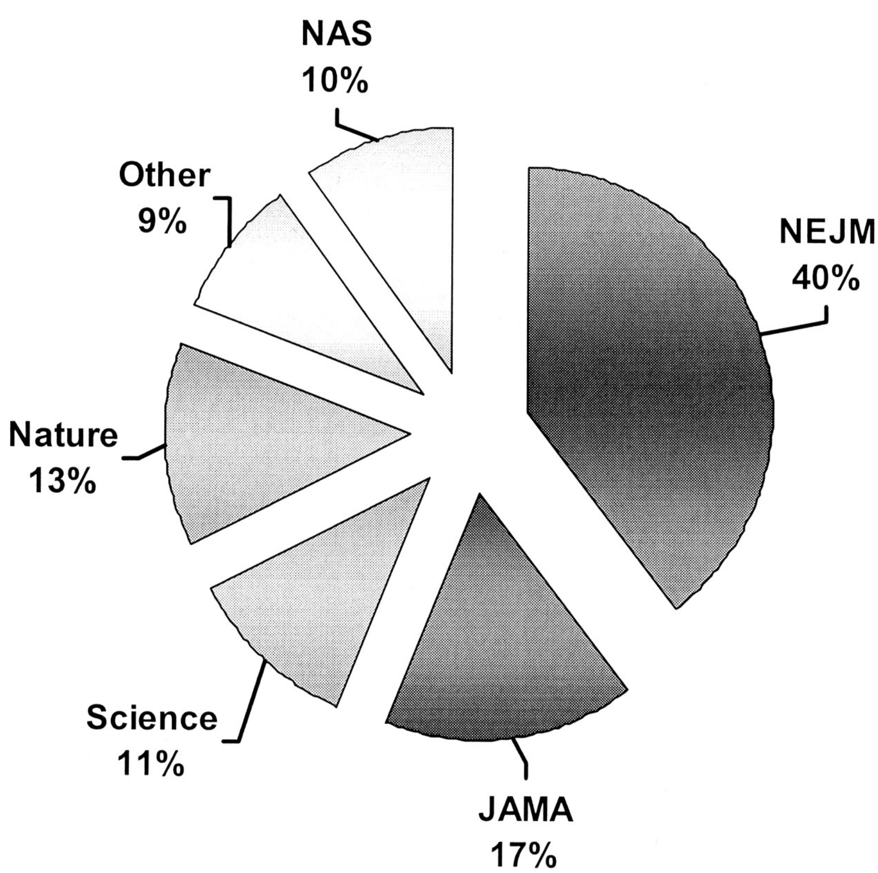

Figure 1. Distribution of scientific journals that published papers that were subsequently reported on in Time and Newsweek in 1990 and 1991.
* this segment represents the portion of articles published that attributed reports from the National Academy of Sciences as the source

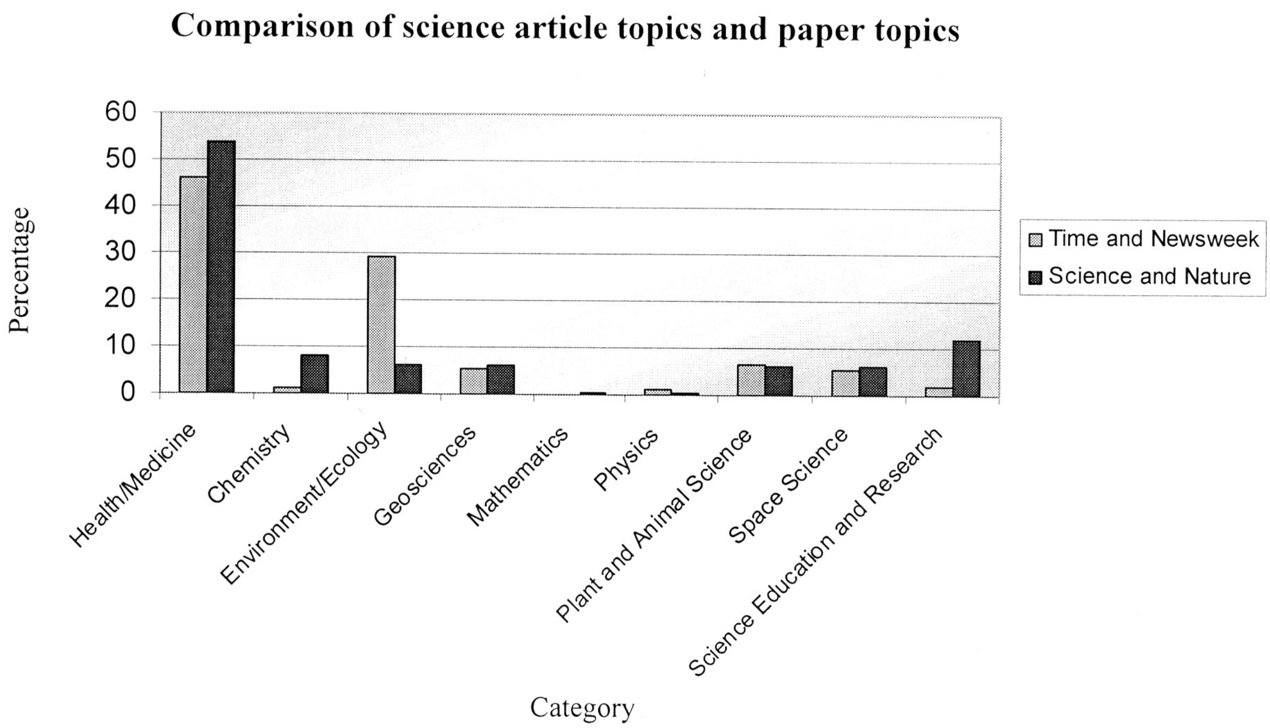

Figure 2. Comparison, by percentage, of the distribution among 9 subject categories, of science articles published in *Time* and *Newsweek* and papers published in *Science* and *Nature*.

Distribution of Citations for Papers Reported in Time and Newsweek

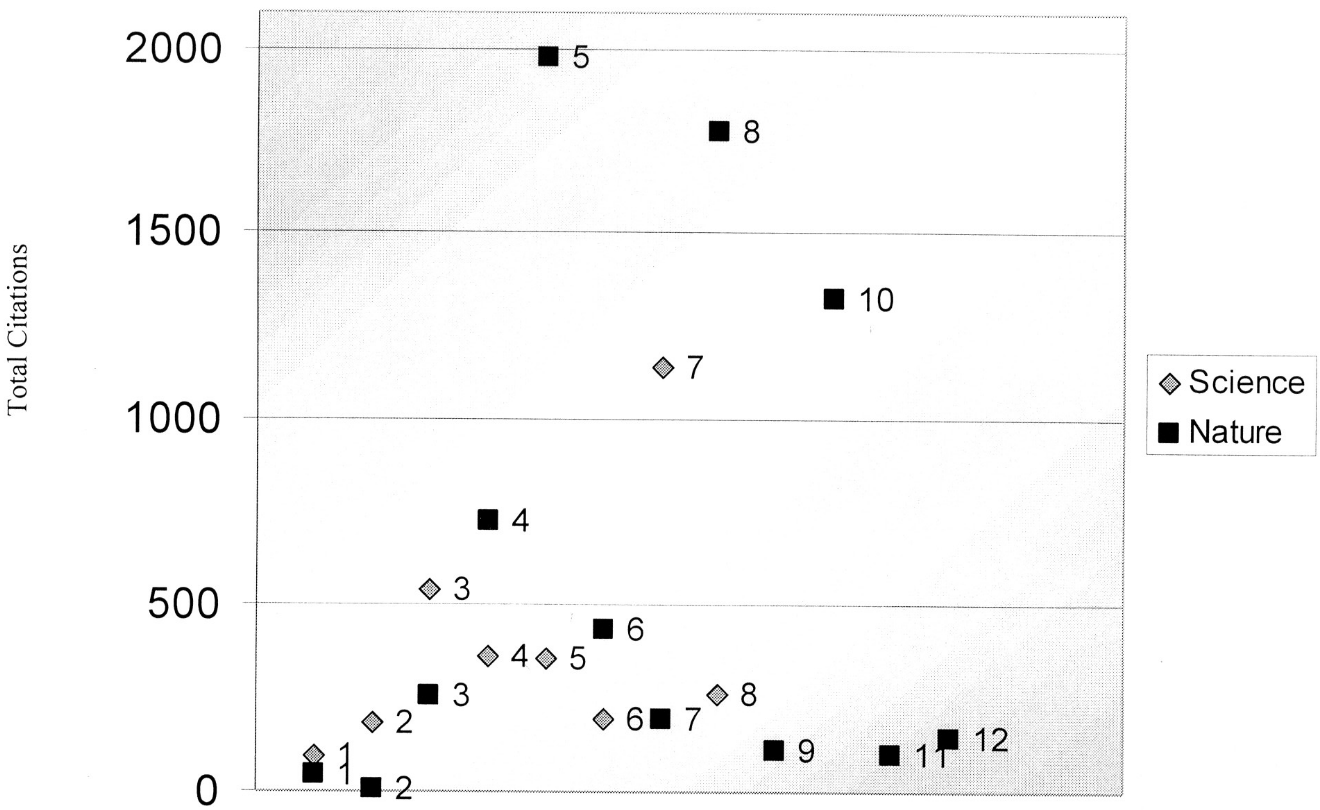

Figure 3. Total citations as of 2004 for papers appearing in *Science* and *Nature* that were subsequently published in *Time* and *Newsweek* in the years 1990-1991.

Legend of Papers

	Science			*Nature*	
1	Ronnett, G. (1990)	93	1	Duller, C. (1991)	47
2	Olshansky, S. (1990)	183	2	Lindley, D. (1991)	4
3	Warren, S. (1991)	540	3	Jenkinson, D. (1990)	257
4	LeVay, S. (1991)	363	4	Bard, E. (1990)	727
5	Naji, A. (1990)	360	5	Goate, A. (1991)	1975
6	Schindler, D. (1990)	197	6	Handyside, A. (1990)	438
7	Hall, J. (1990)	1138	7	Gallo, R. (1991)	194
8	Friischristensen, E. (1991)	265	8	Hebard, A. (1991)	1777
			9	Wayne, R. (1991)	113
			10	Sinclair, A. (1324)	1324
			11	Lyne, A. (1991)	102
			12	Hagelberg, E. (1991)	148

Science Article Categories
Health and medical science*
Chemistry
Environment/Ecology
Geosciences
Mathematics
Physics
Plant and animal science
Space science
Science education and research

Table 1. List of categories that science articles in *Time* and *Newsweek* were assigned. All articles were assigned to one primary category.

* this is a broad category that includes genetics, diseases, biochemistry and other topics that are directly related to health and medicine

Totals of Science Articles Printed in Time and Newsweek by Category		
Category	Author	Number of Citations
Health and medical science*	Handyside, A. (1990)	438
	Goate, A. (1991)	1975
	Gallo, R. (1991)	194
	Sinclair, A. (1324)	1324
	Hagelberg, E. (1991)	148
	Ronnett, G. (1990)	93
	Olshansky, S. (1990)	183
	Warren, S. (1991)	540
	LeVay, S. (1991)	363
	Naji, A. (1990)	360
	Hall, J. (1990)	1138
	Total Citations	6756
Chemistry	Hebard, A. (1991)	1777
	Total Citations	1777
Environment/Ecology	Jenkinson, D. (1990)	257
	Schindler, D. (1990)	197
	Friischristensen, E.. (1991)	265
Geosciences	Duller, C. (1991)	47
	Bard, E. (1990)	727
	Total Citations	1493
	Lindley, D. (1991)	4
Space science	Lyne, A. (1991)	102
	Total Citations	106
Plant and animal science	not represented	
Mathematics	not represented	
Science education and research	not represented	
Physics	not represented	

Table 2. Papers published in Science and Nature that were subsequently reported on in Time and Newsweek with corresponding citation counts according to subject category.

* this is a broad category that includes genetics, diseases, biochemistry and other topics that are directly related to health and medicine

Papers originating in Science or Nature according to category

Category	Number Of articles	Percentage of total
Health and medical science*	255	46.3%
Chemistry	5	1%
Environment/Ecology	162	29.4%
Geosciences	30	5.4%
Mathematics	1	0.1%
Physics	7	1.3%
Plant and animal science	36	6.5%
Space science	29	5.3%
Science education and research	11	2%
Total science articles	551	

Table 3. Totals per category of science-related articles published in *Time* and *Newsweek* in the years 1990-1991assigned to topic categories along with corresponding percentages of the total. All articles were assigned to one primary category.

* this is a broad category that includes genetics, diseases, biochemistry and other topics that are directly related to health and medicine

APPENDIX B

Scientific research is a multi-billion dollar field that produces thousands of scientific discoveries every day. Yet, only a few of those discoveries ever make the news. 90% of Americans want to hear about scientific discoveries, and only 15% feel they are getting that information [1]. A major cause of this failure is simply a lack of communication efforts on the part of scientists.

There is a flourishing world of research existing under the radar of public perception. Thousands of papers are vying for space in thousands of journals, and scientists are reading, critiquing, learning and building on that research, which goes almost unnoticed outside the world of academia. It is common practice for scientists to publish their results in the form of scientific papers in scientific journals, which are read only by other scientists. But, since most of the public gets their news from mass media, this study examined how many of those papers published are ever reported on by mass media outlets. The number was startlingly small. Out of the 1,385,315 papers published by scientists in the years 1990-1991, only 89 were reported on by Time and Newsweek. This shows that there is very little chance of the public learning about a discovery printed in a scientific paper.

When examining what has caused this breakdown in communication, it was learned that scientists make very little effort to communicate to mass media for fear of discrediting themselves, appearing as if they want publicity, distrust of the media, and lack of communication skills. Further, the media is unequipped to decipher highly technical scientific papers, they find scientists by and large inaccessible, and they fail to see the relevance to society, which is often omitted in papers [2].

This study shows that there is a clear need for scientists to develop channels of communication with mass media. Communication of results is an integral part of the scientific process that all scientists adhere to. In light of the results of this study it is impossible to believe that publishing results in the form of a scientific paper is satisfying that obligation. While papers serve an important role in research and development, it is critical for scientists to recognize that alternate forms of communication are necessary in order to communicate science to a willing public.

Some universities have suspected this chasm in communication was a culprit in the public's poor understanding of science and many have instituted communication courses in their science curriculums. Just as writing in a scientific format is a learned skill, rhetorical writing is as well. This study should provide ample evidence for the need of such courses. Unless communication efforts change, the scientific community risks lower support for public funding. Public understanding of science is ranked very low by the National Academy of Sciences, and it should be expected that this trend will continue unless measures are taken within the scientific community to change it [3].

[1] National Science Foundation, Division of Science Resources Statistics. *Science and Engineering Indicators–2002.* Arlington, VA (NSB 02-01) [April 2002].

[2] Hartz, J. and Chappell, R. 1997. World's Apart: How the Distance Between Science and Journalism Threatens America's Future. First Amendment Center, Nashville, 178pp.

[3] National Science Board, National Science Foundation, Division of Science Resources Statistics. *Science and Engineering Indicators 2004.* Arlington, VA (NSB 04-01) [May 2004].